NATIONWIDE AIR POLLUTANT EMISSION TRENDS 1940-1970

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U.S. ENVIRONMENTAL PROTECTION AGENCY

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U.S. ENVIRONMENTAL PROTECTION AGENCY
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ABSTRACT

This report presents estimates of trends in nationwide air pollutant emissions for the five major pollutants: sulfur oxides, particulates, carbon monoxide, hydrocarbons, and nitrogen oxides. Detailed emission estimates for 1969 and 1970 are also provided. The year 1969 was selected as the base year; emissions for other years were calculated using methods and criteria in effect for 1969. In general, emissions of sulfur oxides and nitrogen oxides steadily increased through 1970 while carbon monoxide, particulate, and hydrocarbon emissions peaked in 1968-1969 and either decreased or remained somewhat constant thereafter.

Key Words: trends, emissions, inventory, air pollutants, nationwide, sulfur oxides, carbon monoxide, particulates, hydrocarbons, nitrogen oxides, controllable emissions, miscellaneous emissions.

NATIONWIDE AIR POLLUTANT EMISSION TRENDS 1940-1970

INTRODUCTION

The primary objectives of this publication are to provide current estimates of nationwide emissions for the five major pollutants, sulfur oxides (SO_x), particulates (Part.), carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x), and to present and discuss trends of these emissions. Estimates for 1969 and 1970 are presented in detail, along with summaries of emissions for 1940, 1950, 1960, and 1968.

Reporting of emissions on a nationwide basis, while useful as a general indicator of pollutant levels, has definite limitations. National totals, averages, and trends are not the best guide for estimating the effects that will be produced in a particular locality. Yet, it is important that we establish some criteria in order to measure progress and decide where effort should be channeled. Ideally, nationwide emission estimates should result from a summation of county, state, and regional data in which each component is reported separately. The National Emission Data System (NEDS) now being implemented by the Environmental Protection Agency[1] will provide county, state, and regional data and will include provisions for semiannual updating.

A discussion of trends is meaningful only when there is a common basis for evaluation. It was therefore necessary to quantify emissions using the same criteria for each year. This meant using the same estimation techniques, using equal or equivalent data sources, covering the same pollutant sources, and using the same collection efficiencies where applicable. Emission estimates for previous years were updated by using current emission factors and by including the most recent information available. The criteria used in calculating emissions for 1969 and 1970 were applied to these earlier inventories. Nationwide estimates for these earlier years, except 1966 through 1968,[2] have not been released as separate documents; however, such emission estimates have been published in

air pollutant criteria and control techniques documents, Council on Environmental Quality reports, Economics of Clean Air reports to Congress, and similar releases.

Estimates for 1966 and 1967 were not included in this report because they have been published previously and because they were obtained using methods not consistent with those used in this report; different emission factors and source categories precluded comparisons of data.

This report includes emission estimates through December 1970. It was not possible to obtain more recent estimates because many of the basic data used have time lags of up to 2 years.

Emission estimates in this publication are reported by pollutant for six principal source categories: fuel combustion in stationary sources, transportation, solid waste disposal, industrial process losses, agricultural burning, and miscellaneous. Each of these categories is further broken down into appropriate component parts. All emissions are reported in tons per year to three significant figures. In some instances emission totals may not completely agree due to rounding. Appendices A and B contain a complete set of the data used throughout this report. Appendix A presents detailed emission estimates by pollutant and source category for 1940, 1950, 1960, 1968, 1969, and 1970. Appendix B provides a detailed breakdown of emissions from industrial process losses by pollutant and year.

The basic data used in calculating the emission estimates, such as fuel usage, vehicle miles of travel, and the methodology used, are presented in detail in the Methods section.

NATIONWIDE EMISSION TRENDS
1940-1970

The year 1969 was selected as the base year for presenting and comparing nationwide emissions. Emissions for other years were computed using the same criteria; thus, all years are considered equivalent and valid comparisons are possible.

Emissions during 1969 are considered basically uncontrolled for the gaseous pollutants (CO, HC, NO_X, and SO_X). This does not imply that no controls existed prior to 1969 because many cities and states have had control programs for a number of years. Such programs were, however, restricted mainly to the visible particulate pollutants.

Implementation of motor vehicle controls in the mid 60's began to effect a downward trend in nationwide emissions during 1969 and 1970. As the older uncontrolled vehicles are phased out, and as the more stringent 1975-1976 exhaust emission standards are implemented, a more dramatic downward shift in emissions will be evident.

Table 1 summarizes estimated total emissions for each pollutant by year. Emissions in this table are separated into controllable emissions and miscellaneous emissions. These miscellaneous emissions, which are basically uncontrollable, include emissions from forest fires, structural burning, coal refuse burning, and evaporative losses of gasoline and solvents. These are considered uncontrollable even though man may have an influence, through public awareness programs, safety education, and similar indirect techniques, on the amounts of pollutants emitted from such sources. Many categories of natural emissions could be considered uncontrollable, but estimates of these types of emissions were not available. When comparing emissions over time, however, we are primarily interested in controllable emissions. The division of emissions into controllable and uncontrollable can be rather nebulous since some areas overlap. For this report, controllable emissions are considered basically man-made or man-directed emissions.

Table 1 gives nationwide estimates for controllable emissions. Emissions of sulfur oxides, except in 1960, increased during each reporting interval; CO

Table 1. SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1940-1970
(10^6 tons/year)

Year	Type of emission	SO_x	Part.	CO	HC	NO_x
1940	Controllable	21.3	20.7	66.4	14.6	7.1
	Miscellaneous[a]	0.2	6.4	19.0	4.5	0.8
	Total	21.5	27.1	85.4	19.1	7.9
1950	Controllable	23.6	22.6	93.0	21.4	10.0
	Miscellaneous	0.2	3.3	10.0	4.2	0.4
	Total	23.8	25.9	103.0	25.6	10.4
1960	Controllable	23.0	23.2	121.0	27.2	13.8
	Miscellaneous	0.3	2.1	6.4	4.4	0.2
	Total	23.3	25.3	127.4	31.6	14.0
1968	Controllable	31.0	24.9	145.0	30.3	21.1
	Miscellaneous	0.3	1.7	5.0	4.9	0.2
	Total	31.3	26.6	150.0	35.2	21.3
1969	Controllable	32.2	25.2	148.0	30.2	22.3
	Miscellaneous	0.2	2.1	6.3	5.0	0.2
	Total	32.4	27.3	154.3	35.2	22.5
1970	Controllable	33.6	24.6	144.0	30.3	22.6
	Miscellaneous	0.3	1.0	3.0	4.4	0.1
	Total	33.9	25.6	147.0	34.7	22.7

[a]Miscellaneous emissions are primarily uncontrollable.

levels consistently rose through 1969 and dropped in 1970; particulate emissions followed the same pattern as CO emissions; HC emissions increased until 1968 and remained fairly constant thereafter; and NO_x emissions steadily increased. Detailed discussions of these trends and trends for individual source categories are contained in the following sections.

SULFUR OXIDES

The largest source of sulfur oxides is fuel combustion in stationary sources, and the next largest contributor is industrial process losses. Table 2 summarizes SO_x emissions for the six principal source categories, and Table 3 provides a detailed breakdown for the most important source of SO_x emissions, fuel

Table 2. NATIONWIDE ESTIMATES OF SULFUR OXIDE EMISSIONS, 1940-1970
(10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Fuel combustion in stationary sources	16.8	18.3	17.5	24.7	25.0	26.5
Transportation	0.7	1.0	0.7	1.1	1.1	1.0
Solid waste disposal	Neg[a]	0.1	0.1	0.1	0.2	0.1
Industrial process losses	3.8	4.2	4.7	5.1	5.9	6.0
Agricultural burning	Neg	Neg	Neg	Neg	Neg	Neg
Miscellaneous	0.2	0.2	0.3	0.3	0.2	0.3
Total	21.5	23.8	23.3	31.3	32.4	33.9
Total controllable[b]	21.3	23.6	23.0	31.0	32.2	33.6

[a]Negligible (less than 0.05 x 10^6 tons/year).

[b]Miscellaneous sources not included.

Table 3. SULFUR OXIDE EMISSIONS FROM FUEL COMBUSTION IN STATIONARY SOURCES, 1940-1970
(10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Steam electric	2.8	5.4	10.1	17.4	18.3	19.4
Industrial	9.3	8.2	4.8	4.8	4.6	4.9
Commercial and institutional	1.7	1.8	1.2	1.4	0.8	0.8
Residential	3.0	3.0	1.4	1.2	1.3	1.4
Total	16.8	18.4	17.5	24.8	25.0	26.5

combustion in stationary sources. This source consistently contributes from 76 to 80 percent of the controllable SO_x emissions.

Table 2 shows an unexpected decrease in SO_x emissions for 1960. This decrease is due to two basic factors: (1) residential and industrial use of coal (other than for power generation) dropped sharply during this period and there

was a corresponding increase in the use of natural gas and fuel oil, both of which have lower sulfur contents than coal (the breakdown in Table 3 shows these results), and (2) in the transportation category, vessel use of residual fuel oil dropped considerably. Total SO_x emissions then increased in 1968 and again in 1969 and 1970.

Controllable SO_x emissions increased from 21.3 million tons in 1940 to 33.6 million tons in 1970, a net increase of 58 percent or an average annual gain of nearly 2 percent.

PARTICULATES

Particulate emissions result primarily from fuel combustion in stationary sources and from industrial process losses. Table 4 gives estimates of emissions from the main source categories. Controllable particulate emissions, those not from miscellaneous sources, gradually increased from 1940 through 1969, and subsequently decreased in 1970 due to increased use of particulate control devices.

From 1940 to 1970, an average increase of about 0.6 percent per year occurred, from 20.7 to 24.6 million tons. A much larger increase in particulate

Table 4. NATIONWIDE ESTIMATES OF PARTICULATE EMISSIONS, 1940-1970 (10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Fuel combustion in stationary sources	9.6	9.0	7.6	6.5	6.4	6.8
Transportation	0.4	0.4	0.5	0.8	0.7	0.7
Solid waste disposal	0.4	0.6	1.0	1.4	1.4	1.4
Industrial process losses	8.8	10.8	11.9	13.8	14.3	13.3
Agricultural burning	1.6	1.8	2.1	2.4	2.4	2.4
Miscellaneous	6.4	3.3	2.1	1.7	2.1	1.0
Total	27.1	25.9	25.3	26.6	27.3	25.6
Total controllable[a]	20.7	22.6	23.2	24.9	25.2	24.6

[a]Miscellaneous sources not included.

emissions would have been expected because of increased fuel requirements and other needs that a growing population would incur; however, the application of particulate control devices has resulted in decreased emissions, even though fuel use and industrial output have increased substantially.

CARBON MONOXIDE

The principal contributor of CO emissions is fuel combustion in mobile sources. The percentage of total controllable carbon monoxide emissions from these sources has increased substantially since 1940. Table 5 lists the amounts of CO emitted by the principal source categories. Dramatic overall increases in CO emissions until the late 1960's are due almost exclusively to the increased use of automobiles. Since 1968, automobile emissions have declined because of the installation of emission control devices. Table 6 gives a detailed breakdown of transportation emissions. There has been a steady increase in emissions from uncontrolled nonhighway vehicles such as snowmobiles, tractors, etc. since 1940. Two other important sources of CO emissions are agricultural burning and industrial process losses; emissions from these sources have remained fairly

Table 5. NATIONWIDE ESTIMATES OF CARBON MONOXIDE EMISSIONS, 1940-1970
(10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Fuel combustion in stationary sources	6.2	5.6	2.6	2.0	1.8	0.8
Transportation	34.9	55.4	83.5	113.0	112.0	111.0
Solid waste disposal	1.8	2.6	5.1	8.0	7.9	7.2
Industrial process losses	14.4	18.9	17.7	8.5	12.0	11.4
Agricultural burning	9.1	10.4	12.4	13.9	13.8	13.8
Miscellaneous	19.0	10.0	6.4	5.0	6.3	3.0
Total	85.4	103.0	128.0	150.0	154.0	147.0
Total controllable[a]	66.4	92.9	121.0	145.0	148.0	144.0
Percent of controllable emissions from transportation sources	52.6	59.6	69.0	77.9	75.7	77.1

[a]Miscellaneous sources not included.

Table 6. CARBON MONOXIDE EMISSIONS FROM TRANSPORTATION SOURCES, 1940-1970
(10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Gasoline vehicles	32.1	48.1	73.9	98.4	96.8	95.8
Diesel vehicles	Neg[a]	0.1	0.4	1.0	1.0	0.8
Railroads	Neg	0.1	0.1	0.1	0.1	0.1
Vessels	Neg	Neg	Neg	1.7	1.7	1.7
Aircraft	Neg	1.7	2.1	2.9	2.9	3.0
Other nonhighway use	2.7	5.5	7.0	8.6	9.0	9.5
Total	34.8	55.5	83.5	113.0	112.0	111.0

[a]Negligible (less than 0.05×10^6 tons/year).

constant since 1968. The change in controllable CO emissions from 1940 to 1970, from 66.4 million tons to 144.0 million tons is an overall increase of nearly 117 percent, or nearly 4 percent per year.

Miscellaneous sources such as forest fires, structural fires, and burning in coal-refuse banks have accounted for a large portion of the CO emitted. These are basically uncontrollable emissions and are not considered in discussing trends; they are, however, an important source of carbon monoxide.

HYDROCARBONS

Approximately 65 percent of controllable hydrocarbon emissions are the result of fuel combustion in transportation sources. Emissions from the principal source categories are listed in Table 7, and a detailed breakdown of mobile-source emissions is given in Table 8. Hydrocarbon emissions increased during each reporting period through 1968, after which they remained at about the same level even though the number of vehicles continued to increase. This trend reversal is due to the installation of pollution control devices, which resulted in decreased automotive emissions. Hydrocarbon emissions from nonhighway sources such as farm tractors, construction equipment, utility engines, etc. have shown a continuous upward trend since 1940; however, their contribution has never exceeded 10 percent of the total transportation emissions.

After transportation, the next largest contributor of HC emissions is industrial process losses. The amount of such emissions has not varied greatly over the years, but since 1960 has shown a slight upward trend.

Table 7. NATIONWIDE ESTIMATES OF HYDROCARBON EMISSIONS, 1940-1970 (10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Fuel combustion in stationary sources	1.4	1.3	1.0	1.0	0.9	0.6
Transportation	7.5	11.8	18.0	20.2	19.8	19.5
Solid waste disposal	0.7	0.9	1.3	2.0	2.0	2.0
Industrial process losses	3.3	5.2	4.3	4.4	4.7	5.5
Agricultural burning	1.9	2.1	2.5	2.8	2.8	2.8
Miscellaneous	4.5	4.2	4.4	4.9	5.0	4.4
Total	19.1	25.6	31.6	35.2	35.2	34.7
Total controllable[a]	14.7	21.4	27.2	30.3	30.2	30.3

[a]Miscellaneous sources not included.

Table 8. HYDROCARBON EMISSIONS FROM TRANSPORTATION SOURCES, 1940-1970 (10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Gasoline vehicles	6.9	10.4	16.1	17.4	16.9	16.6
Diesel vehicles	Neg[a]	Neg	0.1	0.2	0.2	0.1
Railroads	Neg	0.1	0.1	0.1	0.1	0.1
Vessels	Neg	Neg	Neg	0.3	0.3	0.3
Aircraft	Neg	0.2	0.3	0.4	0.4	0.4
Other nonhighway use	0.5	1.1	1.4	1.8	1.9	2.0
Total	7.4	11.8	18.0	20.2	19.8	19.5

[a]Negligible (less than 0.05×10^6 tons/year).

Uncontrollable emissions from miscellaneous sources account for roughly 15 to 20 percent of all HC emissions. The quantity of emissions from these sources has been nearly constant since 1940.

NITROGEN OXIDES

Emission of controllable nitrogen oxides almost exclusively results from fuel combustion in mobile and stationary sources; each source category contributes about half of the total amount emitted. Solid waste disposal, industrial process losses, and agricultural burning together account for less than 5 percent of NO_x emissions. Increased NO_x emissions from the manufacture of TNT might have been expected in 1950 and 1968 due to increased arms production; however, such data were not available. Table B-5 in Appendix B lists NO_x emissions from industrial process losses. Nationwide estimates of emissions from the major sources are presented in Table 9, and a detailed breakdown of NO_x emissions from transportation sources is given in Table 10. Controllable nitrogen oxide emissions show a continuing upward trend from 1940 through 1970. Automotive pollution control devices, although helpful in reducing CO and HC emissions, are basically ineffective in reducing NO_x, and in some cases even result in increased NO_x emissions. Thus, we do not see the reduction in NO_x emissions in 1969 and 1970 which occurred in CO and HC emissions during those years.

Table 9. NATIONWIDE ESTIMATES OF NITROGEN OXIDE EMISSIONS, 1940-1970
(10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Fuel combustion in stationary sources	3.5	4.3	5.2	9.7	10.2	10.0
Transportation	3.2	5.2	8.0	10.6	11.2	11.7
Solid waste disposal	0.1	0.2	0.2	0.4	0.4	0.4
Industrial process losses	Neg[a]	0.1	0.1	0.2	0.2	0.2
Agricultural burning	0.2	0.2	0.3	0.3	0.3	0.3
Miscellaneous	0.8	0.4	0.2	0.2	0.2	0.1
Total	7.9	10.4	14.0	21.3	22.5	22.7
Total controllable[b]	7.1	10.0	13.8	21.1	22.3	22.6

[a]Negligible (less than 0.05 x 10^6 tons/year).
[b]Miscellaneous sources not included.

Table 10. NITROGEN OXIDE EMISSIONS FROM TRANSPORTATION SOURCES, 1940-1970
(10^6 tons/year)

Source category	1940	1950	1960	1968	1969	1970
Gasoline vehicles	2.9	4.4	6.8	7.5	7.6	7.8
Diesel vehicles	Neg[a]	0.1	0.4	1.1	1.1	1.3
Railroads	Neg	0.2	0.1	0.1	0.1	0.1
Vessels	0.1	0.1	0.1	0.2	0.2	0.2
Aircraft	Neg	Neg	Neg	Neg	0.4	0.4
Other nonhighway use	0.2	0.4	0.5	1.7	1.8	1.9
Total	3.2	5.2	8.0	10.6	11.2	11.7

[a]Negligible (less than 0.05×10^6 tons/year).

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NATIONWIDE EMISSION ESTIMATES 1969

Nationwide emission estimates of the five major pollutants for 1969 are presented in Table 11.

Table 11. SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1969 (10^6 tons/year)

Source category	SO_x	Particulates	CO	HC	NO_x
Transportation	1.1	0.8	112.0	19.8	11.2
Fuel combustion in stationary sources	25.0	6.4	1.8	0.9	10.2
Industrial process losses	5.9	14.3	12.0	4.7	0.2
Solid waste disposal	0.2	1.4	7.9	2.0	0.4
Agricultural burning	Neg[a]	2.4	13.8	2.8	0.3
Miscellaneous	0.2	2.1	6.3	5.0	0.2
Total	32.4	27.3	154.0	35.2	22.5

[a]Negligible (less than 0.05 x 10^6 tons/year).

SULFUR OXIDES

In 1969, approximately 32.4 million tons of sulfur oxides, primarily SO_2, was emitted in the United States (Table 12). More than 25.0 million tons, or 77 percent of the national total, was produced by the burning of fossil fuels. Combustion of coal accounted for 21.2 million tons and combustion of fuel oil for about 3.8 million tons. Approximately 940 power plants in the country emitted 18.3 million tons, and industrial plants emitted 4.6 million tons. The remaining amount was discharged from the space heating of homes and businesses.

Industrial process losses added an additional 5.9 million tons annually to nationwide SO_x emissions. Four industries contributed a large part of this

Table 12. NATIONWIDE ESTIMATES OF SULFUR OXIDE EMISSIONS, 1969

Source category	Emissions, 10^6 tons/yr	Percent of total
Transportation	1.1	3.4
Motor vehicles	0.3	0.9
Gasoline	0.2	0.6
Diesel	0.1	0.3
Aircraft	0.1	0.3
Railroads	0.2	0.6
Vessels	0.3	0.9
Nonhighway use of motor fuels	0.2	0.6
Fuel combustion in stationary sources	25.0	77.2
Coal	21.2	65.4
Distillate	0.5	1.5
Residual fuel oil	3.3	10.2
Natural gas	Neg[a]	–
Wood	Neg	–
Industrial process losses	5.9	18.2
Solid waste disposal	0.2	0.6
Agricultural burning	Neg	–
Miscellaneous	0.2	0.6
Forest fires	Neg	–
Coal refuse burning	0.2	0.6
Total	32.4	

[a]Negligible (less than 0.05 x 10^6 tons/year).

total: petroleum refineries (0.4 million tons), smelters (4.4 million tons), sulfuric acid manufacturing plants (0.6 million tons), and coking operations (0.5 million tons).

A large percentage of sulfur oxide emissions is concentrated in specific regions of the country. The industrial Northeast, a large contributor, accounts for almost 50 percent of the national total. In these states, coal and residual fuel oil are important sources of heat and power. Other states with estimated emissions of more than 1 million tons per year are Arizona and Texas. In these two states, the primary sources are smelters and refineries, which collectively contribute more than 80 percent of the total SO_x emitted in each state.

About two-thirds of nationwide sulfur oxide emissions occurs in urban areas. Power plants, industries, businesses, and homes all contribute to

emissions in urban areas. Much of the SO_x pollution in rural areas is emitted by a relatively small number of large sources. Smelters, most of which are located away from metropolitan areas, emit large quantities of SO_x. Many of them emit over 100,000 tons per year, and some emit as much as 300,000 to 500,000 tons per year. In addition, almost half of the nation's 940 power plants are located in rural areas and contribute a significant amount of the total nationwide SO_2 emissions.

PARTICULATES

It has been difficult in the past to accurately estimate nationwide particulate pollution because most of such emissions, unlike gaseous emissions, have been under some kind of control. The extent and efficiency of these controls

Table 13. NATIONWIDE ESTIMATES OF PARTICULATE EMISSIONS, 1969

Source category	Emissions, 10^6 tons/yr	Percent of total
Transportation	0.7	2.5
Motor vehicles	0.4	1.4
Gasoline	0.3	1.1
Diesel	0.1	0.4
Aircraft	Neg[a]	--
Railroads	0.1	0.4
Vessels	0.1	0.4
Nonhighway use of motor fuels	0.1	0.4
Fuel combustion in stationary sources	6.4	23.4
Coal	5.6	20.5
Fuel oil	0.4	1.5
Natural gas	0.2	0.7
Wood	0.2	0.7
Industrial process losses	14.3	52.4
Solid waste disposal	1.4	5.1
Agricultural burning	2.4	8.8
Miscellaneous	2.2	7.7
Forest fires	2.0	7.3
Structural fires	0.1	0.4
Coal refuse burning	0.1	0.4
Total	27.3	

[a]Negligible (less than 0.05 x 10^6 tons/year).

were evaluated nationwide in a contract effort recently completed for EPA.[3] This effort also included emission estimates for many previously uninventoried sources.

In 1969, nationwide particulate emissions reached 27.3 million tons (Table 13). Particulate emissions from fuel combustion in stationary sources in 1969 are estimated to total 6.4 million tons. Fuel combustion in power plants and industries resulted in 3.5 million tons and 2.1 million tons, respectively. The burning of coal accounted for 87.5 percent of emissions from fuel combustion.

Industrial process losses are estimated at 14.3 million tons. Iron and steel mill complexes collectively generated some 1.1 million tons of particulate matter. The sand, stone, and rock processing industries, the greatest contributors, emitted 7.0 million tons.

Estimates of particulate emissions in highly industrialized urban areas range from 40,000 tons per year to 500,000 tons per year. Among these areas are Chicago (450,000 tons), Pittsburgh (500,000 tons), and Philadelphia (200,000 tons). Several heavily populated metropolitan areas such as Los Angeles (47,000 tons), Washington (50,000 tons), and Denver (40,000 tons) have lower emission rates due to the absence of heavy industry and coal combustion.

In cities with high levels of particulate emissions, coal combustion and industrial process losses are the principal sources of such emissions. In Pittsburgh, for example, 33 percent of particulate emissions was attributable to stationary fuel combustion and 66 percent to industrial process losses. In Chicago, 76 percent came from coal combustion and 22 percent from industrial process losses.

In cities where emission surveys were conducted recently, nearly every coal-fired power plant was equipped with some kind of control device. This is also essentially true of the larger industrial process sources such as cement plants and iron and steel mills. In contrast, the multitude of smaller sources such as foundries, concrete-batching plants, and grain storage and handling facilities is largely uncontrolled.

CARBON MONOXIDE

In 1969, approximately 154.0 million tons of carbon monoxide was emitted in the United States (Table 14).

Table 14. NATIONWIDE ESTIMATES OF CARBON MONOXIDE EMISSIONS, 1969

Source category	Emissions, 10^6 tons/yr	Percent of total
Transportation	112.0	72.7
Motor vehicles	97.8	63.5
Gasoline	96.8	62.8
Diesel	1.0	0.6
Aircraft	2.9	1.9
Railroads	0.1	0.1
Vessels	1.7	1.1
Nonhighway use of motor fuels	9.0	5.8
Fuel combustion in stationary sources	1.8	1.2
Coal	0.6	0.3
Fuel oil	0.1	0.1
Natural gas	0.1	0.1
Wood	1.0	0.6
Industrial process losses	12.0	7.8
Solid waste disposal	7.9	5.1
Agricultural burning	13.8	9.0
Miscellaneous	6.3	4.0
Forest fires	5.8	3.8
Structural fires	0.2	0.1
Coal refuse burning	0.3	0.2
Total	154.0	

Gasoline-powered motor vehicles constitute the largest single source of CO emissions and account for 96.8 million tons per year, or 62.8 percent of the total amount emitted. The next largest source category includes forest fires, structural fires, agricultural burning, and coal-refuse-bank fires, which collectively emit 20.1 million tons. Industrial sources emit 12 million tons of CO; the largest of these sources include foundries, petroleum refineries, sintering plants, and Kraft paper mills.

Even though vehicular travel is fairly evenly divided between urban and rural areas, traffic in urban areas where slower driving speeds prevail accounts for 64 percent of total motor vehicle emissions. In addition, essentially all industrial emissions, aircraft emissions occurring below 3,000 feet, and a majority of emissions from fuel combustion and refuse disposal occur in urban areas.

HYDROCARBONS

In 1969, approximately 35.2 million tons of hydrocarbons was emitted in the United States (Table 15). Of the sources surveyed, motor vehicles constituted the largest single contributor of HC emissions, accounting for 17.1 million tons per year, or 48.6 percent of the total amount emitted. Miscellaneous sources, including agricultural burning, was the next largest group and accounted for 7.8 million tons.

An estimated 22 million tons, or 62 percent of the national total, was emitted in urban areas. Motor vehicles accounted for 10 million tons of this total. Although vehicular travel will increase rapidly in the next few years, federal control measures should significantly reduce the HC emissions from this source.

Table 15. NATIONWIDE ESTIMATES OF HYDROCARBON EMISSIONS, 1969

Source category	Emissions, 10^6 tons/yr	Percent of total
Transportation	19.8	56.2
Motor vehicles	17.1	48.6
Gasoline	16.9	48.0
Diesel	0.2	0.6
Aircraft	0.4	1.1
Railroads	0.1	0.3
Vessels	0.3	0.8
Nonhighway use of motor fuels	1.9	5.4
Fuel combustion in stationary sources	0.9	2.6
Coal	0.1	0.3
Fuel oil	0.1	0.3
Natural gas	0.3	0.8
Wood	0.4	1.1
Industrial processes	4.7	13.4
Solid waste disposal	2.0	5.7
Agricultural burning	2.7	7.7
Miscellaneous	5.1	14.5
Forest fires	0.5	1.4
Structural fires	0.1	0.3
Coal refuse burning	0.1	0.3
Organic solvent evaporation	3.1	8.8
Gasoline marketing	1.3	3.7
Total	35.2	

NITROGEN OXIDES

In 1969, about 22.5 million tons of NO_x was emitted in the United States (Table 16). Motor vehicles and the burning of coal, oil, and natural gas are the principal sources of NO_x. In 1969, these sources accounted for 18.9 million tons, or almost 84 percent of the national total. Of the 10.2 million tons generated by the stationary combustion of fuels, 4.4 million tons was emitted by power plants, 4.6 million tons by industries, and 1.2 million tons by homes and offices. Burning of natural gas, the largest stationary source, accounted for over 4.5 tons. An estimated 11.2 million tons was emitted by transportation sources; 8.7 million tons of that came from motor vehicles.

Table 16. NATIONWIDE ESTIMATES OF NITROGEN OXIDE EMISSIONS, 1969

Source category	Emissions, 10^6 tons/yr	Percent of total
Transportation	11.2	49.8
Motor vehicles	8.7	38.7
Gasoline	7.6	33.4
Diesel	1.1	4.9
Aircraft	0.4	1.7
Railroads	0.1	0.4
Vessels	0.2	0.9
Nonhighway use of motor fuels	1.8	8.0
Fuel combustion in stationary sources	10.2	45.3
Coal	3.9	17.3
Fuel oil	1.6	7.1
Natural gas	4.5	20.0
Wood	0.2	0.9
Industrial process losses	0.2	0.9
Solid waste disposal	0.4	1.7
Agricultural burning	0.3	1.3
Miscellaneous	0.2	0.9
Forest fires	0.2	0.9
Structural fires	Neg[a]	–
Coal refuse burning	Neg	–
Total	22.5	

[a]Negligible (less than 0.05 x 10^6 tons/year).

Nitrogen oxides and carbon monoxide, probably more than other pollutants, are closely related to the distribution of the population. Combustion in motor vehicles and burning of fuels - coal, fuel oil, natural gas, kerosene, and liquefied petroleum gas - contribute significantly to total nitrogen oxide emissions. It is not surprising, therefore, that over 60 percent of NO_x emissions in the country occur in urban areas; 60 percent of the emissions from fuel combustion and 45 percent of those from motor vehicles occur in urban areas.

NATIONWIDE EMISSION ESTIMATES 1970

Nationwide emission estimates for 1970 are presented in Table 17. In some cases the data presented in this table may differ slightly from the 1970 data discussed in the section entitled Nationwide Emission Trends, 1940-1970. These differences are due to the inclusion of estimates of emissions from prescribed burning; such estimates were not available for earlier years, and therefore were not included in the discussion of trends.

Table 17. SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1970 (10^6 tons/year)

Source category	SO_x	Part.	CO	HC	NO_x
Transportation	1.0	0.7	111.0	19.5	11.7
Fuel combustion in stationary sources	26.5	6.8	0.8	0.6	10.0
Industrial process losses	6.0	13.3	11.4	5.5	0.2
Solid waste disposal	0.1	1.4	7.2	2.0	0.4
Agricultural burning	Neg[a]	2.4	13.8	2.8	0.3
Miscellaneous	0.3	1.5	4.5	4.5	0.2
Total	33.9	26.1	149.0	34.9	22.8

[a]Negligible (less than 0.05×10^6 tons/year).

SULFUR OXIDES

Nationwide sulfur oxide emission estimates for 1970 are contained in Table 18. Fuel combustion in stationary sources, the major contributor, accounted for 26.5 million tons or approximately 78.1 percent of the total amount emitted. Process losses, including those from sulfuric acid production, smelting, petroleum refining, coking, calcium carbide production, and pulp and paper manufacturing, accounted for 17.7 percent of the total sulfur oxides emissions, or 6.0 million tons. The remaining sources listed in Table 18 are responsible for approximately 1.4 million tons, or 4.2 percent of the total.

Table 18. NATIONWIDE ESTIMATES OF SULFUR OXIDE EMISSIONS, 1970

Source category	Emissions, 10^6 tons/year	Percent of total
Transportation	1.0	3.0
Motor vehicles	0.3	0.9
Gasoline	0.2	0.6
Diesel	0.1	0.3
Aircraft	0.1	0.3
Railroads	0.1	0.3
Vessels	0.3	0.9
Nonhighway use of motor fuels	0.2	0.6
Fuel combustion in stationary sources	26.5	78.1
Coal	22.2	65.4
Fuel oil	4.2	12.4
Natural gas	Neg[a]	–
Wood	0.1	0.3
Industrial process losses	6.0	17.7
Solid waste disposal	0.1	0.3
Agricultural burning	0.1	0.3
Miscellaneous	0.2	0.6
Forest fires	Neg	–
Structural fires	Neg	–
Coal refuse burning	0.2	0.6
Total	33.9	

[a]Negligible (less than 0.05 x 10^6 tons/year).

PARTICULATES

The 1970 nationwide particulate emission estimates, by source category, are shown in Table 19. The largest source of nationwide particulate emissions is industrial process losses. These process losses were responsible for 13.3 million tons of particulate matter, or 51 percent of the total emitted. The second most significant source is the combustion of fossil fuel in stationary sources, which accounted for 6.8 million tons of particulates or 26.1 percent of the total. Steam-electric power plants were responsible for the majority of fuel-combustion-generated particulates from stationary sources. Power plants emitted 3.6 million tons collectively in 1970. Agricultural burning, forest fires, and solid waste disposal were responsible for a total of 5.2 million tons. The

Table 19. NATIONWIDE ESTIMATES OF PARTICULATE EMISSIONS, 1970

Source category	Emissions, 10^6 tons/year	Percent of total
Transportation	0.7	2.7
Motor vehicles	0.4	1.5
Gasoline	0.3	1.1
Diesel	0.1	0.4
Aircraft	0.1	0.4
Railroads	Neg[a]	–
Vessels	0.1	0.4
Nonhighway use of motor fuels	0.1	0.4
Fuel combustion in stationary sources	6.8	26.1
Coal	5.6	21.5
Fuel oil	0.4	1.5
Natural gas	0.2	0.8
Wood	0.6	2.3
Industrial process losses	13.3	51.0
Solid waste disposal	1.4	5.3
Agricultural burning	2.4	9.2
Miscellaneous	1.5	5.7
Forest fires[b]	1.4	5.3
Structural fires	Neg	–
Coal refuse burning	0.1	0.4
Total	26.1	

[a]Negligible (less than 0.05 x 10^6 tons/year).
[b]Includes prescribed burning.

remaining 0.8 million tons of particulates came from mobile sources and from coal refuse burning.

CARBON MONOXIDE

Table 20 presents a breakdown, by source category, of 1970 carbon monoxide emissions. The major source is gasoline-powered motor vehicles, which contributed 95.8 million tons of carbon monoxide, or approximately 64.3 percent of the total nationwide emissions. The second largest category, agricultural burning, is responsible for 9.3 percent of the total, or 13.8 million tons. Other important sources include industrial process losses, solid waste disposal, and nonhighway use of motor fuels. These three sources collectively

Table 20. NATIONWIDE ESTIMATES OF CARBON MONOXIDE EMISSIONS, 1970

Source category	Emissions, 10^6 tons/year	Percent of total
Transportation	111.0	74.5
Motor vehicles	96.6	64.8
Gasoline	95.8	64.3
Diesel	0.8	0.5
Aircraft	3.0	2.0
Railroads	0.1	0.1
Vessels	1.7	1.2
Other nonhighway use of motor fuels	9.5	6.4
Fuel combustion in stationary sources	0.8	0.6
Coal	0.5	0.3
Fuel oil	0.1	0.1
Natural gas	0.1	0.1
Wood	0.1	0.1
Industrial process losses	11.4	7.7
Solid waste disposal	7.2	4.9
Agricultural burning	13.8	9.3
Miscellaneous	4.5	3.0
Forest fires[a]	4.0	2.7
Structural fires	0.2	0.1
Coal refuse burning	0.3	0.2
Total	149.0	

[a]Includes prescribed burning.

emitted approximately 28.1 million tons of carbon monoxide in 1970, or 19 percent of the total. Other mobile sources, stationary fuel combustion, and miscellaneous sources account for the remaining 11.3 million tons.

HYDROCARBONS

Table 21 contains a summary of the 1970 nationwide hydrocarbon emissions, by source category. The largest hydrocarbon source, transportation, emitted 19.5 million tons (55.9 percent of the total) in 1970. Other major sources are agricultural burning and evaporative losses of gasoline and solvents, as well as industrial process losses. Combined, these sources contributed 12.8 million tons in 1970. The remaining 2.6 million tons came from solid waste disposal and fuel combustion in stationary sources.

Table 21. NATIONWIDE ESTIMATES OF HYDROCARBON EMISSIONS, 1970

Source category	Emissions, 10^6 tons/year	Percent of total
Transportation	19.5	55.9
Motor vehicles	16.7	47.9
Gasoline	16.6	47.6
Diesel	0.1	0.3
Aircraft	0.4	1.1
Railroads	0.1	0.3
Vessels	0.3	0.9
Nonhighway use of motor fuels	2.0	5.7
Fuel combustion in stationary sources	0.6	1.7
Coal	0.2	0.6
Fuel oil	0.1	0.3
Natural gas	0.3	0.8
Wood	Neg[a]	–
Industrial process losses	5.5	15.8
Solid waste disposal	2.0	5.7
Agricultural burning	2.8	8.0
Miscellaneous	4.5	12.9
Forest fires[b]	0.3	0.9
Structural fires	0.1	0.3
Coal refuse burning	0.1	0.3
Gasoline and solvent evaporation	4.0	11.4
Total	34.9	

[a]Negligible (less than 0.05 x 10^6 tons/year).
[b]Includes prescribed burning.

NITROGEN OXIDES

Nationwide nitrogen oxide emissions for 1970 are presented in Table 22. The major source is transportation, which is responsible for 11.7 million tons of nitrogen oxides, or 51.3 percent of the total amount emitted. Another major source, stationary fuel combustion, produced 10.0 million tons of nitrogen oxides in 1970 or 43.8 percent of the total. Industrial process losses, solid waste disposal, and miscellaneous sources, all minor contributors, accounted for the remaining 1.1 million tons of nitrogen oxides.

Table 22. NATIONWIDE ESTIMATES OF NITROGEN OXIDE EMISSIONS, 1970

Source category	Emissions, 10^6 tons/year	Percent of total
Transportation	11.7	51.3
Motor vehicles	9.1	39.9
Gasoline	7.8	34.2
Diesel	1.3	5.7
Aircraft	0.4	1.8
Railroads	0.1	0.4
Vessels	0.2	0.9
Nonhighway use of motor fuels	1.9	8.3
Fuel combustion in stationary sources	10.0	43.8
Coal	3.9	17.1
Fuel oil	1.3	5.7
Natural gas	4.7	20.6
Wood	0.1	0.4
Industrial process losses	0.2	0.9
Solid waste disposal	0.4	1.8
Agricultural burning	0.3	1.3
Miscellaneous	0.2	0.9
Forest fires[a]	0.2	0.9
Structural fires	Neg[b]	–
Coal refuse burning	Neg	–
Total	22.8	

[a]Includes prescribed burning.
[b]Negligible (less than 0.05 x 10^6 tons/year).

METHODS

The generation of an emission inventory involves many steps to achieve the desired result, which is to estimate the amount of emissions for selected pollutants in a defined geographical area. Because it is impossible to test every pollutant source individually, particularly area sources, an estimating procedure must be used. In order to do this, however, one must either estimate the emissions directly or estimate the magnitude of other variables that can then be related to emissions. These indicators include such things as fuel consumption, vehicle miles, population, sales, tons of refuse burned, raw materials processed, etc., which are then multiplied by appropriate emission factors[4] to obtain emission estimates.

The limitations and applicability of emission factors must be understood. In general, emission factors are not precise indicators of emissions from a single source; rather, they are quantitative estimates of the average rate of pollutant release as a result of some activity. They are most valid when applied to a large number of sources and processes. If their limitations are recognized, emission factors are extremely useful in determining emission levels. A detailed discussion of emission factors and related information is contained in *Compilation of Air Pollutant Emission Factors.*

The emission factor thus relates quantity of pollutants emitted to indicators such as those noted above, and is a practical approach for determining estimates of emissions from various source categories.

The methodology used in generation of emissions estimates for individual source categories follows.

TRANSPORTATION

Motor Vehicles

Emission estimates from gasoline-powered motor vehicles were obtained by two basic approaches. Both were necessary because a complete list of emission factors was not available for SO_X and particulates, as it was for CO, HC, and NO_X.

Estimates of CO, HC, and NO_X were based upon vehicle-mile tabulations and upon emission factors developed from both road and cycle data.[5] An example of the distribution of vehicle miles by vehicle-type and location is presented in Table 23. The emission factors used account for variations in emissions due to type, speed, age, transmission, size of engine, and size of vehicle.

Estimates of SO_X and particulate emissions were based on total, nationwide vehicle miles of travel. An average particulate emission factor and an average sulfur content of gasoline were applied to the mileage.[4] The average emission factors used to obtain estimates in this report were based on data presented in *Compilation of Air Pollutant Emission Factors.*

Table 23. VEHICLE MILES OF TRAVEL IN THE UNITED STATES, 1969 (10^9 miles)

Type of vehicle	Urban	Rural	Total
Passenger cars	455.55	410.51	866.06
Light-duty trucks[a]	33.46	50.20	83.66
Heavy-duty trucks			
Class II[b]	9.34	14.02	23.36
Class III[c]	6.23	9.34	15.57
Class IV[d,e]			
Gasoline	11.72	28.71	40.43
Diesel	9.20	23.10	32.30
Total	525.50	535.88	1,061.38

[a]Under 6,000 pounds.
[b]6,000 to 10,000 pounds.
[c]10,000 to 19,000 pounds.
[d]Over 19,000 pounds.
[e]Includes buses.

Emissions from diesel-powered motor vehicles were based on fuel consumption data because road-emission data were lacking. Average factors were applied to the gallons of diesel fuel consumed by motor vehicles.[6]

Aircraft

The emissions in this category were determined from the results of a recent extensive study.[7] Estimates of all pollutants, except sulfur oxides, were presented for emissions at all altitudes based on the number of flights made by different types of aircraft. Sulfur oxide emissions were calculated by assuming that aircraft fuels contain an average of 0.055 percent sulfur.

Railroads

The annual fuel consumption by railroads includes consumption of diesel fuel as well as distillate and residual fuel oils.[8] The average emission factors applicable to diesel fuel combustion, except those for SO_x, were assumed to be applicable also to residual and distillate fuel oils. The average sulfur content of each fuel was used in estimating SO_x emissions.

Vessels

Ships and vessels consume diesel fuel, residual fuel oil, gasoline, and coal.[8,9] Reported usage figures represent quantities sold in this country rather than quantities consumed; thus, the quantities of fuels actually consumed within the United States are probably considerably less, with the exception of gasoline. Emission factors available for this category are based on average emission factors applicable to other types of combustion.

Nonhighway Use of Motor Fuels

The nonhighway consumption of motor fuels includes consumption of gasoline and diesel fuel. Average emission factors for gasoline and diesel combustion were used. Consumption in the aviation and marine categories was excluded from this section since these sources were included previously.

FUEL COMBUSTION IN STATIONARY SOURCES

Coal

Bituminous coal, lignite, and anthracite coal are consumed in the United States in stationary sources. (This excludes that consumed by such mobile sources as railroads, ships, and vessels.[9]) Table 24 presents an example of annual consumption by user category. Average emission factors and the sulfur content of fuels for each category were used to estimate emissions. Degree of particulate control was based on a report by Midwest Research Institute.[3]

Table 24. FUEL CONSUMPTION IN STATIONARY SOURCES, 1969

Source category	Coal, 10^6 tons/yr	Fuel oil, 10^6 bbl/yr		Total gas, 10^9 ft^3/yr
		Residual	Distillate	
Electric utilities	310.3	247.6	12.2	3,486
Coke plants	92.9	--	--	--
Steel and rolling mills	6.8	--	--	--
Cement mills	9.3	--	--	--
Oil companies, gas pipelines, and gas transmission	--	36.5	13.9	4,001
Other manufacturing	79.6	130.6	42.4	7,612
Military	--	31.7	14.0	--
Residential, commercial, institutional, and light industrial	16.9	187.0	524.3	6,982[a]
Total	515.8	633.4	606.8	22,081

[a]Does not include light industrial sources.

Fuel Oil

Distillate and residual fuel oils are consumed in large quantities nationwide by stationary sources. Table 24 presents an example of annual consumption by user category. Average emission factors and the sulfur content of fuels for each category were used to estimate emissions. It was assumed that there are no SO_x controls on sources of fuel oil combustion.

Natural Gas

Total gas consumption, 99 percent of which consists of consumption of natural gas, is given for 1969, an example year, in Table 24.[10] Average emission factors and the sulfur content of fuels were used to estimate emissions.

Wood

Wood consumption by user category was not available. However, estimates of the total energy produced by wood combustion could be determined.[11] Assuming 9,000 Btu per pound of wood, the quantity of wood burned can then be estimated. Average emission factors were used to estimate total emissions.

INDUSTRIAL PROCESS LOSSES

In addition to fuel combustion, certain other industrial processes generate and emit varying quantities of pollutants into the air. The lack of published national data on production, type of equipment, and controls, as well as an absence of emission factors, makes it impossible to include estimates of emissions from all industrial process sources.

Table 25 summarizes, as an example, the 1969 production of the various industrial processes surveyed.[12] In all cases, emission estimates were obtained by applying average emission factors to total production amounts, when they were available. Various degrees of control were used, as outlined in a report by Midwest Research Institute.[3]

Table 25. SUMMARY OF INDUSTRIAL PRODUCTION, 1969

Source category	Production, 10^3 tons (except as noted)
Iron and steel mills	141,000
Coke manufacture	65,000
Gray iron foundries	24,400
Aluminum primary	3,793
Copper primary	1,550
Lead primary	639
Zinc primary	1,500
Miscellaneous secondary metals	--
Petroleum refineries	$3{,}900 \times 10^6$ bbl
Cement	$408{,}000 \times 10^6$ bbl
Acid manufacture	
Phosphoric	4,900
Nitric	6,200
Sulfuric	29,000
Hydrochloric	1,800
Mineral industries	2,665,000
Explosives	--
Petrochemicals	--
Cotton	9.9×10^6 bales
Pulp mills, Kraft and NSSC[a]	28,800
Grain handling	177,000
Grain milling	100,000

[a]Neutral sulfite semichemical.

SOLID WASTE DISPOSAL

A study conducted in 1968 on solid waste collection and disposal practices was the basis for estimating emissions from solid waste disposal.[13] Results of this study indicate that the average collection rate of solid waste is about 5.5 pounds per capita per day in the United States. It has been stated that a conservative estimate of the total generation rate is 10 pounds per capita per day.

The results of this survey were used to estimate, by disposal method, the quantities of solid waste generated. Average emission factors were applied to these totals to obtain estimates of total emissions from the disposal of solid wastes.

MISCELLANEOUS SOURCES

Forest Fires

The Forest Service of the Department of Agriculture publishes information on the number of forest fires and the amount of controlled burning that occurs in the United States.[14] These data indicate the number of acres of forest fires that occurred each year. Average emission factors were applied to the quantities of combustible materials burned to arrive at estimated emissions.

Structural Fires

The United States Department of Commerce publishes in their statistical abstracts information on the number and types of structures damaged by fire.[15] This information was supplemented by data from the National Fire Protection Association or local fire departments. Emissions were then estimated by applying average emission factors to these totals.

Coal Refuse

Estimates of the number of burning, coal-refuse piles existing in the United States are made periodically by the Bureau of Mines.[16] Their publication, *Coal Refuse Fires, An Environmental Hazard,* presents a detailed discussion of the nature, origin, and extent of this source of pollution. Rough estimates of the quantity of emissions were obtained using this information.

Organic Solvent Evaporation

Insufficient national data were available to permit accurate estimation of hydrocarbon emissions from organic solvent evaporation. A rough estimate of nationwide emissions was made from an average per capita rate based on data gathered in four metropolitan areas: Los Angeles, San Francisco, St. Louis, and Washington, D.C. One-third of the total HC emissions is attributed to evaporation of the solvents handled by the paint and varnish industry, for which estimates of gallons handled and resultant emissions were available.

Gasoline Marketing

Estimates of the evaporation of motor fuels during the filling of tank vehicles, service station tanks, and automobile tanks are included in this section. Other sources of evaporation are the evaporation of gasoline from storage tanks at refineries and bulk terminals and evaporation during the operation of motor vehicles. These emissions were included in the petroleum refinery and motor vehicle sections. Average evaporation factors were applied to the amount of gasoline and diesel fuel consumed in order to estimate hydrocarbon emissions from gasoline marketing.

Agricultural Burning

Large quantities of agricultural refuse are burned annually in the United States. Estimates of the amounts burned were obtained from state agricultural departments or extension services. Emissions estimates were obtained by applying factors to these rough totals.

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APPENDIX A
DETAILED NATIONWIDE EMISSION ESTIMATES, 1940-1970

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Table A-1. DETAILED SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1940
(10^3 tons/year)

Source category	SO_x	Part.	CO	HC	NO_x
Fuel combustion in stationary sources					
Steam-electric	2,860	1,980	25	14	595
Industrial	9,310	6,180	177	109	1,940
Commercial and institutional	1,680	358	13	13	60
Residential	2,960	1,040	6,030	1,250	942
Total fuel	16,800	9,560	6,250	1,380	3,530
Transportation					
Gasoline vehicles	60	99	32,100	6,940	2,900
Diesel vehicles	5	2	34	7	36
Total road vehicles	65	101	32,100	6,950	2,900
Railroads	288	33	5	11	7
Vessels	306	210	10	12	97
Aircraft	1	Neg[a]	23	3	1
Other nonhighway use	40	7	2,690	521	179
Total transportation	700	351	34,900	7,500	3,220
Solid waste disposal					
Municipal incineration	9	41	81	6	6
On-site incineration	14	136	282	146	22
Open burning	17	269	1,430	505	101
Conical burning	–	–	–	–	–
Total solid waste	40	446	1,790	657	129
Industrial process losses	3,770	8,820	14,400	3,280	29
Agricultural burning	–	1,580	9,110	1,860	197
Total controllable	21,300	20,700	66,400	14,700	7,110
Miscellaneous					
Forest fires	–	5,930	17,700	1,410	699
Structural fires	–	31	120	37	4
Coal refuse burning	–	400	1,200	240	48
Organic solvent	–	–	–	1,980	–
Gasoline marketing	–	–	–	789	–
Total miscellaneous	240	6,360	19,000	4,460	751
Total all categories	21,500	27,100	85,400	19,100	7,860

[a]Negligible (less than 0.05×10^6 tons/year).

Table A-2. DETAILED SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1950
(10^3 tons/year)

Source category	SO_x	Part.	CO	HC	NO_x
Fuel combustion in stationary sources					
Steam-electric	5,360	2,950	44	36	1,220
Industrial	8,160	4,640	172	153	2,020
Commercial and institutional	1,840	386	27	20	113
Residential	2,970	986	5,380	1,130	970
Total fuel	18,300	8,960	5,620	1,340	4,330
Transportation					
Gasoline vehicles	90	150	48,100	10,400	4,410
Diesel vehicles	12	6	83	18	87
Total road vehicles	102	156	48,200	10,400	4,500
Railroads	413	55	71	61	211
Vessels	358	155	11	13	126
Aircraft	31	43	1,690	236	13
Other nonhighway use	80	14	5,520	1,070	368
Total transportation	984	424	55,400	11,800	5,210
Solid waste disposal					
Municipal incineration	14	63	125	10	9
On-site incineration	21	209	433	225	34
Open burning	24	378	2,010	709	142
Conical burning	–	–	–	–	–
Total solid waste	59	650	2,570	944	185
Industrial process losses	4,210	10,800	18,900	5,170	55
Agricultural burning	–	1,800	10,400	2,140	225
Total controllable	23,600	22,600	92,900	21,400	10,000
Miscellaneous					
Forest fires	–	2,910	8,670	693	343
Structural fires	–	35	133	41	4
Coal refuse burning	–	400	1,200	240	48
Organic solvent	–	–	–	2,270	–
Gasoline marketing	–	–	–	903	–
Total miscellaneous	250	3,340	10,000	4,150	395
Total all categories	23,800	25,900	103,000	25,600	10,400

Table A-3. DETAILED SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1960
(10^3 tons/year)

Source category	SO_x	Part.	CO	HC	NO_x
Fuel combustion in stationary sources					
Steam-electric	10,100	4,440	88	69	2,290
Industrial	4,800	2,350	139	197	1,780
Commercial and institutional	1,210	253	54	39	204
Residential	1,380	593	2,290	713	877
Total fuel	17,500	7,630	2,570	1,020	5,150
Transportation					
Gasoline vehicles	141	234	73,900	16,100	6,850
Diesel vehicles	55	31	398	86	416
Total road vehicles	196	265	74,300	16,200	7,270
Railroads	150	48	127	99	148
Vessels	187	86	13	13	74
Aircraft	32	54	2,060	283	16
Other nonhighway use	110	18	7,050	1,360	470
Total transportation	675	471	83,600	18,000	7,980
Solid waste disposal					
Municipal incineration	22	101	198	15	15
On-site incineration	33	333	691	358	54
Open burning	27	424	2,250	795	159
Conical burning	2	151	1,970	166	15
Total solid waste	84	1,010	5,110	1,330	243
Industrial process losses	4,720	11,900	17,700	4,280	82
Agricultural burning	–	2,140	12,400	2,530	267
Total controllable	23,000	23,200	121,000	27,200	13,800
Miscellaneous					
Forest fires	–	1,680	5,000	405	198
Structural fires	–	39	148	45	4
Coal refuse burning	–	400	1,200	240	48
Organic solvent	–	–	–	2,690	–
Gasoline marketing	–	–	–	1,070	–
Total miscellaneous	274	2,120	6,350	4,450	250
Total all categories	23,300	25,300	128,000	31,600	14,000

Table A-4. DETAILED SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1968
(10^3 tons/year)

Source category	SO_x	Part.	CO	HC	NO_x
Fuel combustion in stationary sources					
Steam-electric	17,400	3,460	70	28	4,170
Industrial	4,750	2,240	154	53	3,750
Commercial and institutional	1,390	261	66	184	980
Residential	1,210	534	1,670	614	810
Total fuel	24,700	6,500	1,960	979	9,710
Transportation					
Gasoline vehicles	200	300	98,400	17,400	7,500
Diesel vehicles	100	100	1,000	200	1,100
Total road vehicles	300	400	99,400	17,600	8,600
Railroads	200	100	100	100	100
Vessels	300	100	1,700	300	200
Aircraft	100	100	2,900	400	40
Other nonhighway use	200	100	8,600	1,800	1,700
Total transportation	1,100	800	113,000	20,200	10,600
Solid waste disposal					
Municipal incineration	–	87	280	22	22
On-site incineration	–	359	750	390	59
Open burning	80	656	3,480	1,230	246
Conical burning	–	297	3,500	320	38
Total solid waste	80	1,400	8,010	1,960	360
Industrial process losses	5,080	13,800	8,520	4,370	173
Agricultural burning	–	2,400	13,900	2,840	300
Total controllable	31,000	24,900	145,000	30,300	21,100
Miscellaneous					
Forest fires	–	1,220	3,640	291	144
Structural fires	–	43	166	51	5
Coal refuse burning	–	400	1,200	240	48
Organic solvent	–	–	–	3,100	–
Gasoline marketing	–	–	–	1,200	–
Total miscellaneous	290	1,660	5,010	4,880	197
Total all categories	31,300	26,600	150,000	35,200	21,300

Table A-5. DETAILED SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1969
(10^3 tons/year)

Source category	SO_x	Part.	CO	HC	NO_x
Fuel combustion in stationary sources					
Steam-electric	18,300	3,550	157	144	4,350
Industrial	4,560	2,130	74	192	4,550
Commercial and institutional	793	433	100	44	440
Residential	1,310	250	1,450	520	910
Total fuel	25,000	6,360	1,780	900	10,200
Transportation					
Gasoline vehicles	200	300	96,800	16,900	7,600
Diesel vehicles	100	100	1,000	200	1,100
Total road vehicles	300	400	97,800	17,100	8,700
Railroads	200	67	100	100	100
Vessels	300	59	1,700	300	200
Aircraft	100	50	2,900	400	400
Other nonhighway use	200	103	9,000	1,900	1,800
Total transportation	1,100	719	112,000	19,800	11,200
Solid waste disposal					
Municipal incineration	–	87	280	22	22
On-site incineration	–	361	750	392	59
Open burning	–	646	3,430	1,210	242
Conical burning	–	304	3,400	330	39
Total solid waste	187	1,400	7,860	1,950	362
Industrial process losses	5,870	14,300	12,000	4,740	213
Agricultural burning	–	2,400	13,800	2,750	300
Total controllable	32,200	25,200	148,000	30,200	22,300
Miscellaneous					
Forest fires	–	1,960	5,750	460	230
Structural fires	–	60	220	67	4
Coal refuse burning	–	115	300	100	14
Organic solvent	–	–	–	3,100	–
Gasoline marketing	–	–	–	1,300	–
Total miscellaneous	197	2,140	6,270	5,030	248
Total all categories	32,400	27,300	154,000	35,200	22,500

Table A-6. DETAILED SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1970
(10^3 tons/year)

Source category	SO_x	Part.	CO	HC	NO_x
Fuel combustion in stationary sources					
Steam-electric	19,400	3,700	162	140	4,710
Industrial	4,890	2,140	73	272	4,530
Commercial and institutional	815	132	170	55	225
Residential	1,350	879	385	148	565
Total fuel	26,500	6,850	790	615	10,000
Transportation					
Gasoline vehicles	200	300	95,800	16,600	7,800
Diesel vehicles	100	100	800	100	1,300
Total road vehicles	300	400	96,600	16,700	9,100
Railroads	124	47	100	93	142
Vessels	297	51	1,700	317	162
Aircraft	100	49	3,000	420	364
Other nonhighway use	163	108	9,500	2,000	1,920
Total transportation	984	655	111,000	19,500	11,700
Solid waste disposal					
Municipal incineration	15	144	350	15	20
On-site incineration	34	338	450	248	45
Open burning	53	840	4,470	1,580	315
Conical burning	2	105	1,950	165	15
Total solid waste	104	1,430	7,220	2,000	395
Industrial process losses	6,030	13,300	11,400	5,470	199
Agricultural burning	–	2,400	13,800	2,750	275
Total controllable	33,600	24,600	144,000	30,300	22,600
Miscellaneous					
Forest fires	–	835	2,460	197	98
Structural fires	–	57	220	67	7
Coal refuse burning	–	110	340	68	34
Organic solvent	–	–	–	3,050	–
Gasoline marketing	–	–	–	1,010	–
Total miscellaneous	279	1,000	3,020	4,390	139
Total all categories	33,900	25,600	147,000	34,700	22,700

APPENDIX B
EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1940-1970

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Table B-1. SULFUR OXIDE EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1940-1970
(10^3 tons/year)

Source	1940	1950	1960	1968	1969	1970
Pulp and paper	22	37	63	68	78	77
Calcium carbide	Neg[a]	Neg	Neg	Neg	Neg	2
Sulfuric acid	196	293	347	568	580	474
Coking	278	352	341	461	461	474
Petroleum refining						
FCC[b]	123	201	286	310	358	354
TCC[c]	2	3	5	5	6	5
Metals						
Copper	2,030	2,030	2,540	2,750	3,410	3,570
Zinc and lead	1,120	1,290	1,140	916	977	944
Total	3,770	4,210	4,720	5,080	5,870	6,030

[a]Negligible (less than 0.05×10^6 tons/year).
[b]Fluid catalytic cracking.
[c]Thermal catalytic cracking.

Table B-2. PARTICULATE EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1940-1970
(10^3 tons/year)

Source	1940	1950	1960	1968	1969	1970
Iron and steel						
Blast furnace	1,850	1,560	800	71	76	74
Open hearth	392	437	191	125	26	20
Basic oxygen furnace	Neg[a]	Neg	23	455	14	15
Electric arc	6	21	9	22	20	20
Sintering	420	529	588	693	704	1,270
Scarfing	20	88	135	128	128	146
Mining iron ore	82	110	99	96	99	100
Coke						
By-product	97	123	119	161	161	166
Beehive	310	580	100	120	120	140
Storage pile losses	58	78	96	130	138	134
Primary metals						
Aluminum	5	30	48	15	119	125
Copper	81	107	150	187	245	280
Zinc	154	200	28	9	21	20
Lead	15	15	11	14	15	16
Secondary metals						
Grey iron foundries	–	–	–	–	259	233
Aluminum	Neg	1	1	2	55	51

Table B-2 (continued). PARTICULATE EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1940-1970
(10^3 tons/year)

Source	1940	1950	1960	1968	1969	1970
Lead	6	11	9	4	4	4
Zinc	3	4	2	3	4	5
Copper	7	13	12	52	54	51
Brass and bronze	7	11	5	–	–	–
Mineral products industries						
Cement	686	961	1,040	867	897	1,120
Sand and gravel	2	2	4	46	47	47
Stone and rock crushing	1,620	2,330	4,470	6,550	6,890	4,190
Phosphate rock	83	115	67	63	58	59
Clay	–	–	–	–	147	137
Lime	418	559	832	998	1,090	1,060
Calcium carbide	–	–	–	–	8	8
Perlite	–	–	–	–	5	5
Asphalt batching	–	–	–	–	446	525
Concrete batching	–	–	–	–	10	20
Coal cleaning	104	19	138	785	226	218
Carbon black	290	486	194	94	82	72
Gypsum	–	–	–	–	–	38
Asphalt roofing	–	–	–	–	2	2
Chemical industry						
Sulfuric acid	Neg	Neg	Neg	Neg	14	14

Table B-2 (continued). PARTICULATE EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1940-1970
(10^3 tons/year)

Source	1940	1950	1960	1968	1969	1970
Phosphoric acid	Neg	Neg	Neg	5	Neg	Neg
Oil refining	15	24	35	88	44	42
Miscellaneous process sources						
Cotton gining	113	77	90	32	61	21
Pulp and paper	613	903	962	369	424	549
Grain handling	1,360	1,410	1,660	1,690	1,490	1,590
Feed mills	–	–	–	–	71	513
Ferroalloys	–	–	–	–	53	47
Silicon metals	–	–	–	–	16	17
Fertilizers	–	–	–	–	–	166
Total	8,820	10,800	11,900	13,800	14,300	13,300

[a]Negligible (less than 0.05×10^6 tons/year).

Table B-3. CARBON MONOXIDE EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1940-1970
(10^3 tons/year)

Source	1940	1950	1960	1968	1969	1970
Grey iron foundries[a]	–	–	–	–	1,770	1,740
Petroleum refineries						
FCC	3,200	5,250	3,740	2,020	2,340	2,310
TCC	127	208	148	84	84	83
Fluid coking	2,000	1,640	2,340	140	140	137
Carbon black						
Furnace - gas	95	775	726	405	405	382
Furnace - oil	Neg[b]	202	1,360	2,480	2,480	2,500
Channel	4,160	5,170	2,450	1,260	1,110	955
Thermal	Neg	Neg	Neg	Neg	Neg	Neg
Formaldehyde	5	21	50	102	105	108
Steel manufacturing	4,480	5,040	5,990	3,500	–	–
Sintering sinter	–	–	–	–	1,100	917
Sintering - pellets	–	–	–	–	1,290	1,080
Basic oxygen furnace	–	–	–	–	128	137
Coke						
Beehive	2	3	1	1	1	1
By-product	35	45	43	58	58	60
Pulp and paper	314	520	886	945	966	999
Total	14,400	18,900	17,700	8,520	12,000	11,400

[a]Data for 1940 through 1968 are included under steel manufacturing.
[b]Negligible (less than 0.05×10^6 tons/year).

Table B-4. HYDROCARBON EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1940-1970
(10^3 tons/year)

Source	1940	1950	1960	1968	1969	1970
Petroleum refineries	1,680	2,880	2,710	2,780	2,300	2,960
Natural gas liquids	–	–	–	–	700	810
Photochemicals	–	–	–	–	200	222
Coke						
By-products	117	148	143	193	193	199
Beehive	12	23	4	5	5	6
Carbon black						
Furnace - oil	–	18	121	220	220	222
Furnace - gas	32	263	247	138	138	130
Channel	1,430	1,770	840	431	380	328
Ammonia	9	72	219	603	600	589
Total	3,280	5,170	4,280	4,370	4,740	5,470

Table B-5. NITROGEN OXIDE EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1940-1970
(10^3 tons/year)

Source	1940	1950	1960	1968	1969	1970
Nitric acid	9	25	43	110	111	114
Sulfuric acid	4	5	3	24	29	12
Petroleum refining	15	24	34	37	43	43
TNT[a]	–	–	–	–	28	28
Coke	1	1	1	2	2	2
Total	29	55	82	173	213	199

[a]Data not available prior to 1969.

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